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tainty in the case of the very high luminosity stars than in any of the others. It is probable that after such a revision has been made the method will find its most important application as a means of distinguishing these giant stars in the stellar system.

Mount Wilson Solar Observatory,
January, 1916.

THE DIURNAL VARIATION OF THE REFRACTION.

By R. H. Tucker.

The question of diurnal variation in the amount of the atmospheric refraction is not entirely a new one. But there are still points of novelty in its consideration, and the references to the subject are mostly rather vague, with but little data of definite value. It has been conceded that each observing station may require special treatment, and this is especially likely for one of the elevation of Mount Hamilton. Every observation of a standard star, made here, has been reduced in such a manner as to present, in the derived value of the latitude, a contribution to the refraction correction. For many years these values agree in giving a smaller value of the refractions during the night observations, than that of the Poulkova constant, which is already considerably smaller than that of Bessel, long adopted for meridian work in the large observatories of the world.

In the preliminary reductions of the fundamental work, carried on here from 1905 to 1908, it became evident that the value of the refraction in daytime observing was different from that of the night hours, and the subject was thoroly discussed, for the years 1905 and 1906 in *L. O. Bulletin* No. 231, published in April, 1913.

The variation there derived was based upon the combination of the extreme southern stars, and north stars at lower culmination, in two programs, differing twelve hours in right ascension. The separate stars, up to 80° zenith distance south, and 83° north, were also treated individually, for comparison of the effect of spectral type. No dependence upon type, or magnitude, or zenith distance, or position north or south, could be traced in the various combination; which agree in giving a total difference between day and night refractions, which is in the neighborhood of $0''.5$ tan. Z. D., or about one per cênt. of the total refraction.

The observations of those years were planned for every hour of the day and night, but some gaps unavoidably occurred in the months of bad observing weather. Also, since the principal object at the time was considered to be the observation of the azimuth, and the derivation of the position of the meridian mark and its variations, the zenith distances were not always observed at the transit near noon, the unsteadiness of the stars being so great that the results were likely to be very uncertain. Since the development of the diurnal change in the refraction, the noon observations are necessary to fill in the curve of the variation in daytime, and these observations will be made in this year, if weather conditions permit The original series gives determinations extending from three and a half hours before sunset, to over four hours following sunrise. *Polaris* and *β Ursæ Majoris* can be observed at noon; but even the brightest stars can not be observed in full daylight at low altitudes, where the density of the atmosphere renders the absorption too great for their visibility. I commonly reckon that the brightness is reduced by five magnitudes at the zenith in daylight, another magnitude at zenith distance 70°, and over two magnitudes at 80°. The unsteadiness at even moderate zenith distances adds greatly to the difficulty of making daytime observations, for the faint object actually disappears entirely under bad conditions. The full program of stars extended an hour beyond the daylight limits mentioned above, but the zenith distances of all but ten stars were too small for profitable discussion of refraction errors. The present series will include night observations, those in full daylight, and the necessary check determinations upon other stars near sunrise and sunset. Meantime, a test has been made of the earlier observations of *Polaris* in combination with *β Ursæ Majoris,* both of which transit near the same time, at opposite culminations. These two stars are of similar spectral type, tho the zenith distances are not great enough to introduce any sensible atmospheric dispersion. Observations of *α Andromedae* were always made in the same series, which gives a check value of the instantaneous latitude, independent of errors of nadir reading and of the Variation of Latitude. From the respective probable errors, I estimate such a determination of the zenith point as of three times the weight of nadir direct.

The combination of *Polaris* U. C. and *β Urs. Maj.* L. C. gives a difference of tangents of zenith distance = 1.23, which is of course very small in comparison with the single stars at low altitudes, which gave tangent factors six or more times as large; doubled again in the combination of north and south stars, upon which the final result was based. The combination also of four circumpolar stars, of declinations 60° to 70° gave differential tangent factors, at the two culminations, of from 4 to 8, for a check computation of the variation. In any of the direct comparisons the declination errors are included, but these are fully eliminated in the comparison of day and night results. Thus, the combination above described gives the following corrections to the Poulkova Refractions:

21 Daytime observations,	+0″.27 tan Z. D.
19 Night "	+0 .17 " "
Difference (D-N)	+0 .10 " "

Two daytime differences, nearly balancing in effect, were excluded from the computation, as their respective residuals exceed four times the probable error of a single value.

The combination of *Polaris* L. C. and *β Urs. Maj.* U. C. is not nearly as strong, as the difference of tangents is only 0.59, and should have one-fourth the weight of the first combination, depending upon the squares of the respective factors. The probable error of a single determination of the refraction correction in the first, is one-third that of the second combination. This last gives the corrections to the Poulkova Refractions:

17 Daytime observations,	+1″.44 tan Z. D.
17 Night "	+0 .42 " "
Difference (D-N)	+1 .02 " "

The weighted mean of I and II is, D — N = +0.″28 tan Z. D. from 76 series.

During the year 1905-06 a full 100 transits were obtained of *Polaris,* and the accompanying stars, but the zenith distance observations were omitted for a portion of the transits. This weighted result is in fair accord with the much stronger value of the discussion in the published Bulletin. There is a slight progressive change during the night, and a very rapid change near sunrise and sunset; the mean result for daytime falls within two hours of these two epochs and accordingly the full effect of the change does not appear in the mean differences. It has given a better illustration of the effect to reckon from sunrise and sunset, rather than from noon, as the length of the day changes so greatly with the seasons; and the effect may be believed to be due to the action of the Sun, while above the horizon, in changing the refractive influence of the air strata from that computed for the temperatures given by our thermometers at the surface of the Earth. The actual recorded temperatures, and their changes up or down, during the hours of observation, were shown, in the earlier discussion, to have no direct influence upon the general result.

To illustrate the conformity of the variation at different zenith distances, the results of the full list of stars in the two programs are tabulated below. The greater part of all meridian work is done at night, and the discussion of daytime refraction corrections has practical value only in connection with fundamental work, which must be carried thru the twenty-four hours. In the differential determination all other sources of error have been quite completely eliminated. In the original reductions, the graduation errors measured for all the divisions employed (*L. O. Pub.* Vol. X), have been applied, but even these corrections are eliminated in the comparison. For south stars, the errors of the standard declinations adopted enter the direct determination of the refraction correction, but are eliminated in the differential comparison. For circumpolar stars it is theoretically possible to eliminate the errors of assumed declinations, by observing both the culminations; but, practically, we have to deal with two determinations under varying conditions, with different nadir readings, graduation errors and widely different zenith distances at the two culminations. The only safe course is to arrange the reduction of the observations so as to eliminate every error except the accidental errors of observation, which are diminished in effect as we increase the number of determinations, up to the point of practical efficiency. Astronomical literature bears the burden of numerous discussions, these days, assuming the failure of methods of observation, due to accidental refraction errors, to sluggish levels, and to various defects in the instruments employed. In contrast, we are here dealing with a practical source of error, the effect of which can be determined and accounted for.

Diurnal variation at all Zenith Distances (D-N).

4 South	Stars,	Z. D.	76°.7,,	correction,	+0″.28	tan	Z. D.
14 ΔT	"	"	41 .1	"	+0 .17	"	"
4 Z	"	"	1 .4		....		
5 U. C.	"	"	25 .2	"	−0 .20	"	"
5 L. C.	"	"	78 .2	"	+0 .32	"	"
Polaris		"	52 .6	"	+0 .58	"	"

The mean, with weights proportional to the tangents is +0″.30 tan Z. D.; and with weights proportional to the squares of the tangents it is +0″.31 tan Z. D. The full difference, with daylight observations extended to noon, will be considerably larger.

The daytime observations, besides the difficulty of making them, have very much larger accidental errors than those made under the favorable conditions generally prevailing at night. The rapidly moving south stars are more difficult to see than the comparatively slow moving north stars, and the atmospheric glare facing south makes a very considerable difference. Thus, second magnitude stars are often impossible at moderate zenith distances south, while north stars of similar brightness and altitude are comparatively easy to observe. In general, from experience at three other important observing stations, the daytime conditions at Mount Hamilton can be described as the worst of all the stations, while night conditions are often the best experienced at any of them.

It is a curious anomaly, here, noticed generally in daytime, that the stars south of the zenith are comparatively steadier than those north, when a southerly wind prevails; and the reverse conditions are noticed when a northerly wind prevails.

March 15, 1916.